

**Title** Quantitative relationships between different injury factors and development of brown rot caused by *Monilinia fructigena* in integrated and organic apple orchards

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### Abstract

In a 4-year study, the incidence of various types of injuries (caused by insects, birds, growth cracks, mechanical wounding, and other, unidentified factors) was assessed in relation to brown rot development (caused by *Monilinia fructigena*) on fruit of three apple cultivars (Prima, Jonathan, and Mutsu) in integrated and organic blocks of two apple orchards in Hungary. In addition, populations of male codling moths (*Cydia pomonella*) were monitored with pheromone traps season-long in both management systems. On average, injury incidence on fruit at harvest was 6.1 and 19.2% in the integrated and organic treatments, respectively. Insect injury, which was caused primarily by *C. pomonella*, had the highest incidence among the five injury types, accounting for 79.4% of the total injury by harvest in the organic blocks and 36.6% in the integrated blocks. Levels of all other injury types remained close to zero during most of the season, but the incidence of bird injury and growth cracks increased markedly in the final 3 to 5 weeks before harvest in both production systems. Brown rot developed more slowly and reached a lower incidence in the integrated (6.4% final incidence on average) compared with the organic blocks (20.1% average incidence). In addition, the disease developed later but attained higher levels as the cultivar ripening season increased from early-maturing Prima to late-maturing Mutsu. Overall, 94.3 to 98.7% of all injured fruit were also infected by *M. fructigena*, whereas the incidence of brown-rotted fruit without visible injury was very low (0.8 to 1.6%). Correlation coefficients (on a per plot basis) and association indices (on a per-fruit basis) were calculated between brown rot and the various injury types for two selected assessment dates 4 weeks preharvest and at harvest. At both dates, the strongest significant ( $P < 0.05$ ) relationships were observed between brown rot and insect injury and between brown rot and the cumulative number of trapped *C. pomonella*. At the harvest assessment, two additional significant correlations were between brown rot and bird injury and between brown rot and growth cracks. In every case, correlation coefficients were larger in organic than in integrated blocks. Although it is well established that brown rot in pome fruits is closely associated with fruit injuries, this is the first study to

provide season-long progress data on different injury types and quantitative analyses of their relative importance at different times in the growing season and across two distinct management systems.